September 5, 2011

DAIKIN SERVICE MANUAL NEWS

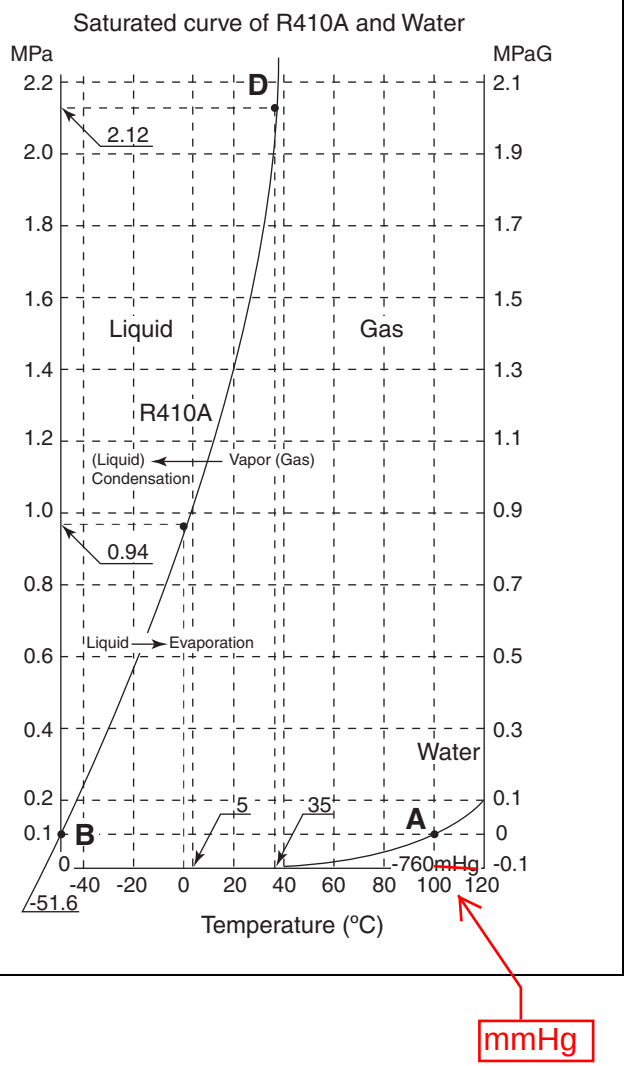
★Reliable technology ensures maximum customer satisfaction.★ **M-11011**

Case	Correction of Service Manual Si-18
Model	Air Conditioning and Refrigeration Equipment

Please refer attached pages for correction of service manual Si-18.

At Point B, the R410A refrigerant of 0.1MPa boils at a temperature of -51.6°C.
Therefore, at **Point D**, if the R410A refrigerant having a temperature of 35°C is in a state of saturated vapor at the pressure of 2.12MPa, it becomes refrigerant saturated liquid of 35°C by removing the condensation latent heat from the said saturated vapor.
By contrast, at Point C, that means it is required to reduce the pressure down to 0.94MPa in order to boil the R410A refrigerant at 5°C.

Fig.1-33



1.3.5 Sensible heat and latent heat

Fig. 1-34 shows the "temperatue-heat content diagram" for 1kg of water heated from -50°C to 150°C vapor under the atmospheric pressure.

(1) From A to B, 105.4kJ(25.2kcal) of heat were added to increase ice temperature from-50°C to 0°C.
(2) From B to C, 333.2kJ(79.6kcal) were added to melt ice without changing its temperature.
(3) From C to D, 418.6kJ(100kcal) were added to heat water to boiling point. (from 0°C to 100°C)
(4) From D to E, 2256kJ(539kcal) were added to change water to vapor without changing its temperature.
(5) From E to F, 92.5kJ(22.1kcal) were added to increase vapor temperature from 100°C to 150°C.

In this example,

- The heat which was required to increase the ice temperature is called "sensible heat". (A to B)
- The heat which was required to change the ice to water is called "latent heat of melting". (B to C)
- The heat which was required to increase the water temperature is also called "sensible heat". (C to D)
- The heat which was required to change the water to steam is called "latent heat of vaporization". (D to E)

If the process is reversed,

- The heat which must be rejected to change the steam to water is called "latent heat of condensation". (E to D)
- The heat which must be rejected to decrease the water temperature is called "sensible heat". (D to C)
- The heat which must be rejected to change the water to ice is called "latent heat of solidification". (C to B)
- The heat which must be rejected to decrease the ice temperature is called "sensible heat". (B to A)

Fig.1-34

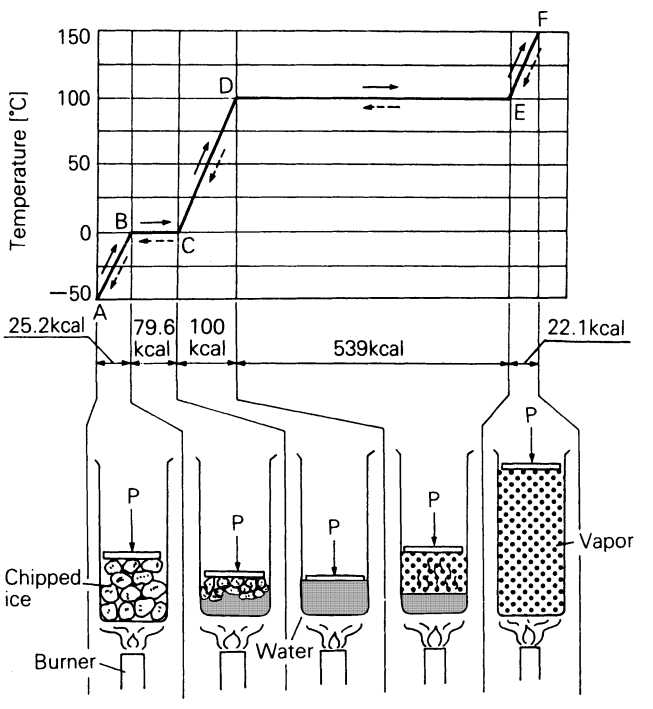
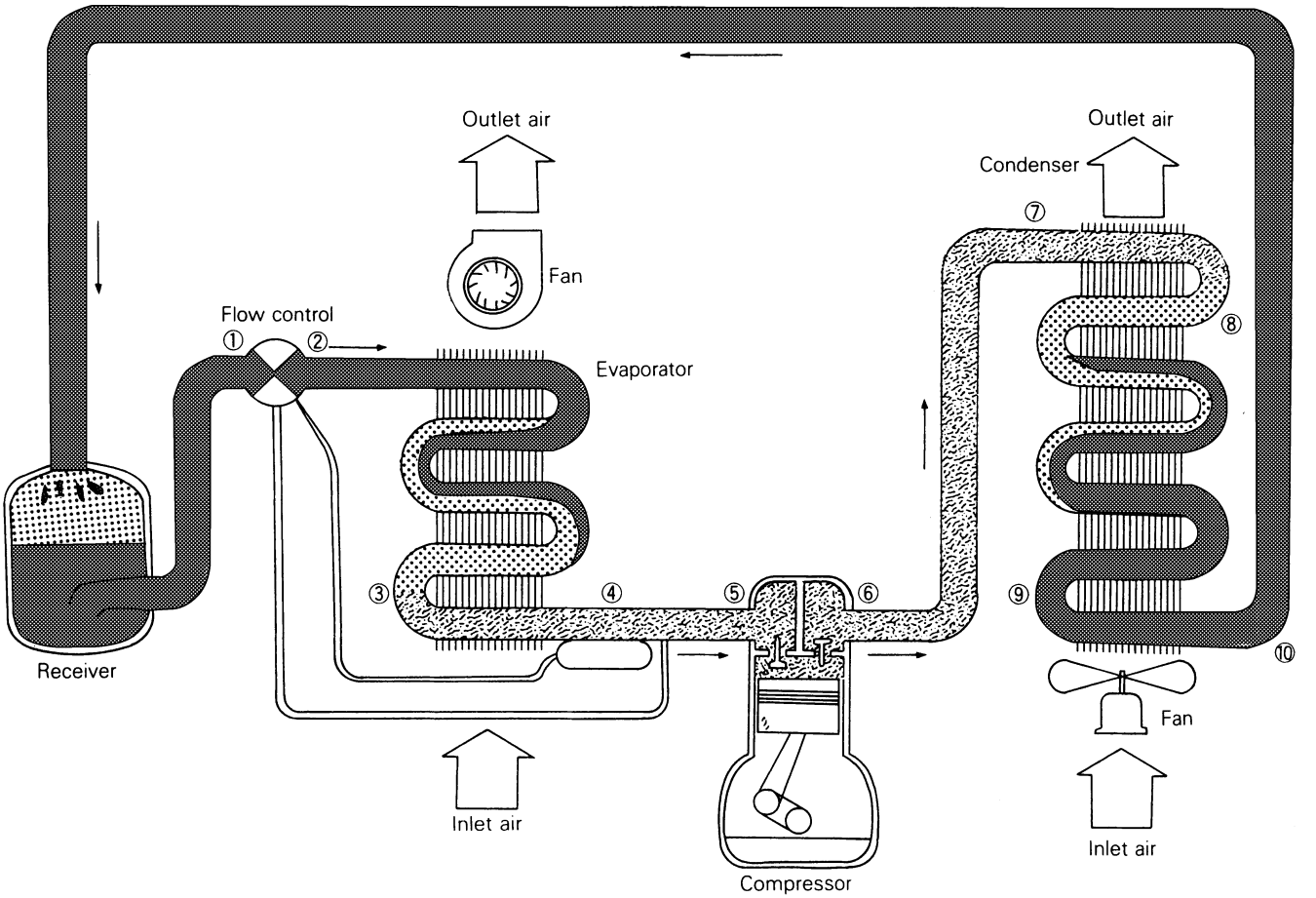
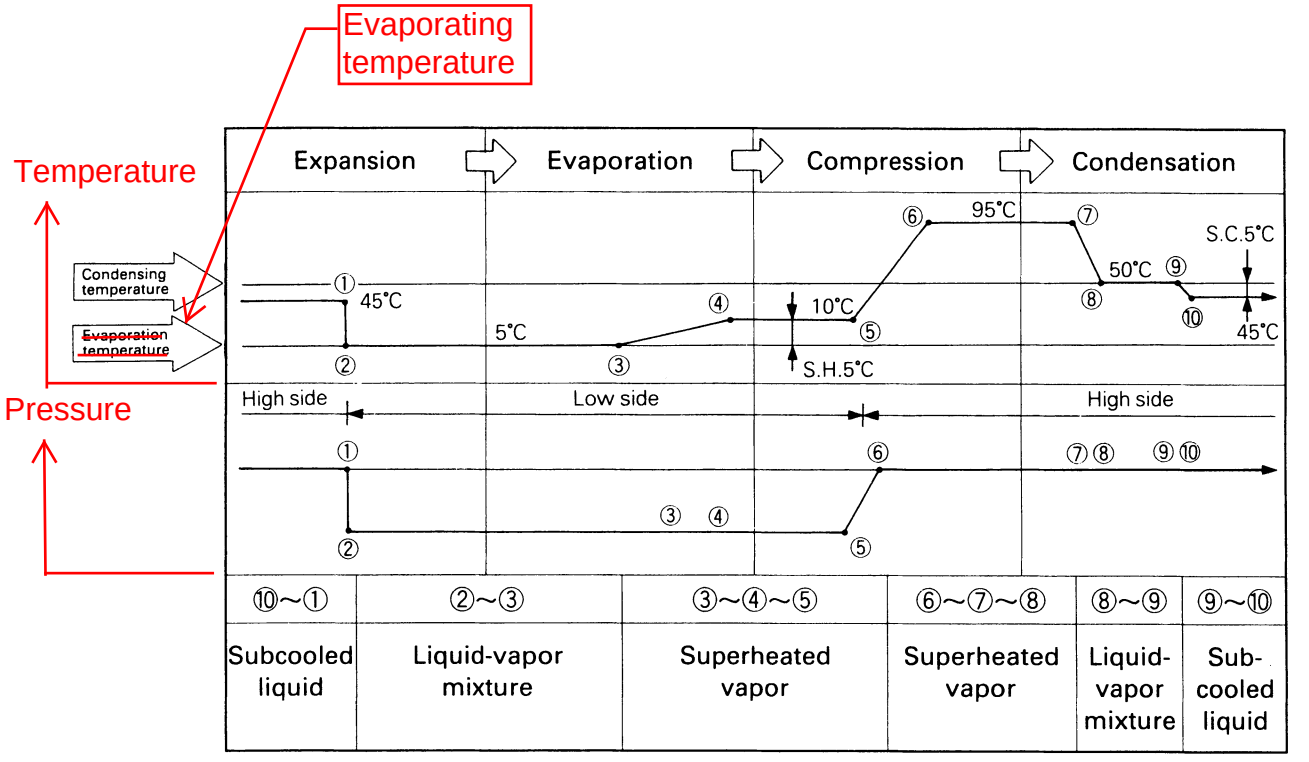


Fig.1-53


Outlet air
Fan
Flow control
①
②
Evaporator
Receiver
③
④
⑤
⑥
Inlet air
Compressor
Outlet air
Condenser
⑦
⑧
⑨
⑩
Fan
Inlet air


Evaporating temperature
Temperature
Pressure
Condensing temperature
Evaporation temperature
Expansion
Evaporation
Compression
Condensation
45°C
5°C
10°C
95°C
50°C
S.C.5°C
45°C
S.H.5°C
High side
Low side
High side
⑩~①
②~③
③~④~⑤
⑥~⑦~⑧
⑧~⑨
⑨~⑩
Subcooled liquid
Liquid-vapor mixture
Superheated vapor
Superheated vapor
Liquid-vapor mixture
Sub-cooled liquid

Chapter 2 Mollier chart

The state of refrigerant in a refrigeration cycle varies with a wide range of conditions while an air conditioner or a chiller is in operation.
When the changes in state under these conditions are plotted on a chart, each state and the numerical values of the state in every part of the equipment can be estimated.
Furthermore, the capacity or the operating state can be estimated using these values. This chart is called the P-h Chart.
The vertical axis of the P-h Chart specifies the pressure (P), and the horizontal axis specifies the specific enthalpy (h). The P-h Chart is therefore sometimes referred to as "Pressure-enthalpy Chart". Furthermore, this Chart has received another name derived from the name of the inventor of the Chart, that is, "Mollier (or "Morieru" in Japanese) Chart".
The P-h Chart consists of 8 kinds of lines in all; saturated liquid line, saturated vapor line, constant temperature lines, constant specific volume lines, constant dryness lines and constant specific entropy lines as well as constant pressure lines and constant enthalpy lines. It looks like a map, which shows the refrigerant properties diagrammatically. The methods of drawing the lines vary to some extent with the types of refrigerants, while the basic method of reading the lines does not vary. In this textbook, the R22 refrigerant (fluorocarbon: HCFC22, most-often used for air conditioning), is used as the teaching material.
Furthermore, SI unit (International System of Units) is used to represent the unit.

2.1 Composition of P-h Chart

2.1.1 Pressure: P [MPa abs]

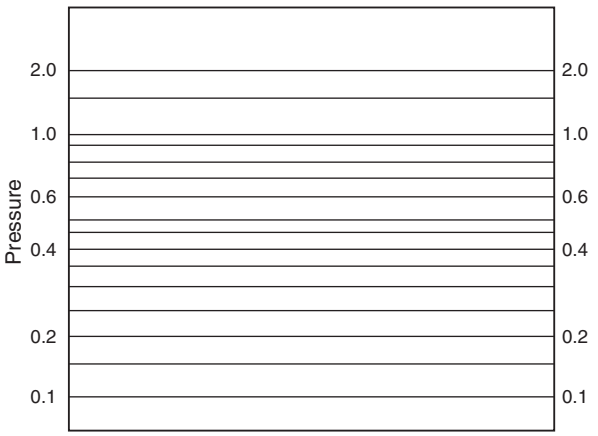
In the P-h Chart, pressure is graduated on the vertical axis. Therefore, horizontal lines represent constant pressure lines; and all points on the same horizontal line show the same pressure.
The scale is logarithmic but not required to be bound for use. The pressure scale is expressed in the value of absolute pressure.

Absolute pressure = Gauge pressure + Atmospheric pressure
[MPa abs] = [MPa G] + 0.1 [MPa abs]

Note: Under normal conditions, the "abs" of "MPa abs" is often omitted. In this textbook, however, the "abs" consciously remains shown for ease of understanding.

P-h Chart (R407C)

Fig.2-1



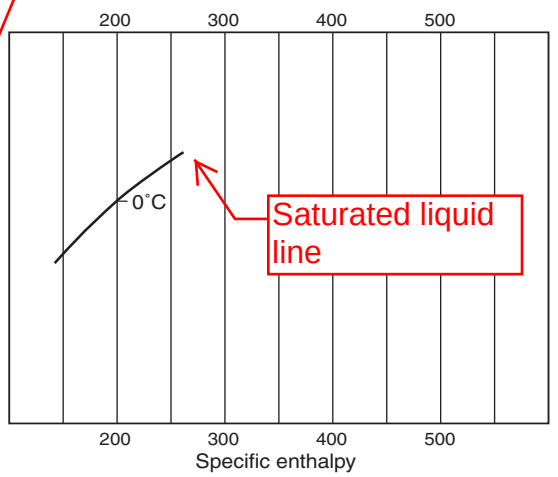
Q. 1

Chiller is operating with the use of R22 refrigerant. The low pressure gauge shows 0.5MPa G and the high pressure gauge shows 1.7MPa G. Show each of these pressures on the P-h Chart using horizontal lines.

2.1.2 Specific enthalpy: h [kJ/kg]

The specific enthalpy is graduated on the horizontal axis. Therefore, constant specific enthalpy lines are shown with vertical lines. This scale is proportionally graduated. Therefore, the numerical values must be read as accurately as possible.
The specific enthalpy is the sum of internal energy and work energy; which can be defined as the total amount of heat held by the refrigerant in a given state.
On the ~~P-h Chart~~, the specific enthalpy of 1 kg mass of saturated liquid at 0°C is defined as 200 kJ/kg.

Fig.2-2

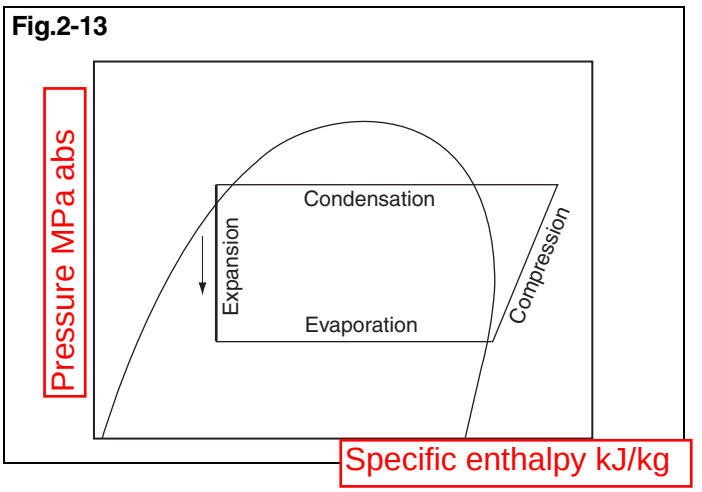


Note: The specific enthalpy is scientifically defined as:

h = ue + Pv

h: Specific enthalpy
ue: Internal energy
P: Absolute pressure
v: Specific volume

Fig.2-13



2.2.2 How to draw actual operating state on P-h Chart

In order to draw the refrigeration cycle on the P-h Chart, the following four operating conditions are required. In other words, if the four conditions are known, the refrigeration cycle can be drawn on the P-h Chart.

Conditions:

1. Evaporating pressure or evaporating temperature
2. Suction gas temperature or superheated degree
3. Condensing pressure or condensing temperature
4. Liquid temperature at expansion valve inlet or sub-cooled degree

Superheated degree = Suction gas temperature - Evaporating temperature

Sub-cooled degree = Condensing temperature - Liquid temperature at expansion valve inlet

■ Procedure

Draw the refrigeration cycle on the R22 P-h Chart based on the following operating conditions.

Conditions:

Evaporating temperature = 6°C

Condensing temperature = 36°C

Superheated degree = 5°C

Liquid temperature at expansion valve inlet = 31°C

1. Evaporation process

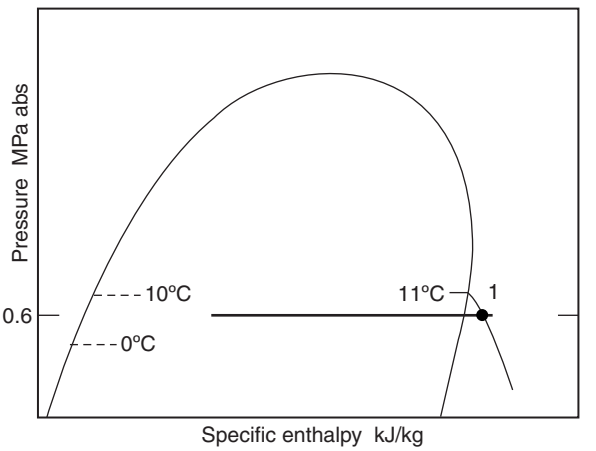
Even though the refrigeration cycle can be started to draw from anywhere on the P-h Chart, it is usually started from the compressor suction point, that is, the completion point of the evaporation process.

Since the evaporating temperature is 6°C, a horizontal line is drawn from the 6°C graduations on the saturated liquid line and the saturated vapor line. The starting point of the evaporation process has not yet been known at this stage. Therefore, the horizontal line may be tentatively drawn to the right from a point with a dryness factor of about 0.4.

The evaporation process is represented with a horizontal line due to changes under constant pressure. In this case, the pressure is 0.6MPa abs, which is referred to as the evaporating (or low) pressure.

Check the superheated degree given in the above conditions to determine the point where the refrigerant is discharged from the evaporator and sucked into the compressor. In this case, since the superheated degree is 5°C, the suction gas temperature rises by 5°C from the evaporating temperature of 6°C, thus reaching a temperature of 11°C. The pressure is kept constant up to this point, therefore the Point 1 of intersection of the extension of the constant pressure line of 0.6MPa abs and the 11°C constant temperature line that tilts toward the right by 1°C from the 10°C constant temperature line is taken as the suction point of the compressor.

Fig.2-14



Note: Strictly speaking, the pressure varies while showing a slight drop in the evaporation process, while the pressure is assumed to be constant on the P-h Chart.

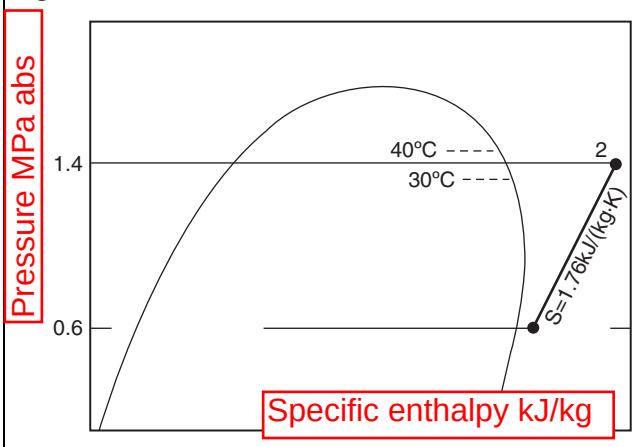
2. Compression process

The compression process starts from the Point 1. While in this process, a line is drawn according to the changes of the constant specific entropy, that is, in parallel with the specific entropy line up to the Point 2 of intersection with the line of condensing pressure (high pressure) of 1.4MPa abs corresponding to 36°C condensing temperature.

Whereas, this specific entropy line is slightly curved, and the Point 1 does not always comes on the specific entropy line on the Chart. Therefore, it is practical to find the Point 2 according to a position on the condensing pressure line having the numerical value of specific entropy equal to that at the Point 1 and draw the line of the compression process by connecting the Points 1 and 2.

The Point 2 represents the discharge gas state from the compressor.

Fig.2-15



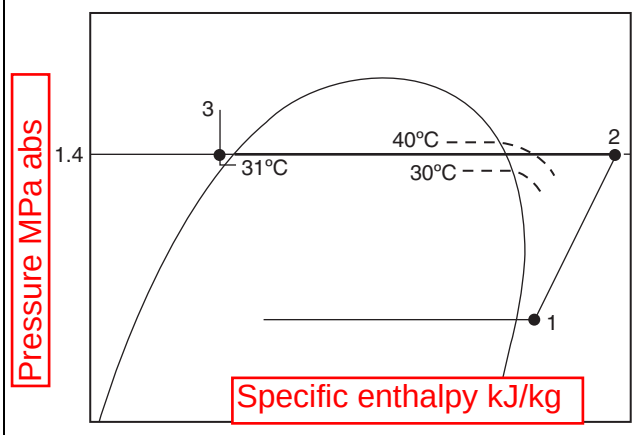
Note: The compression process is drawn as theoretical adiabatic compression. Therefore, it may be slightly different from that in actual operation.

3. Condensation process

The condensation process starts from the Point 2. Heat exchange in this process is performed mostly in the condenser, but the condensation process itself starts at the discharge point of the compressor.

At the Point 2, the condensing (high) pressure is 1.4MPa abs, which is equal to the condensing temperature of 36°C. Since the condensation process is a heat radiation process under constant pressure, draw a line horizontally to the left from the Point 2. While in the condensation process, the refrigerant changes from superheated vapor to moist vapor, and further to sub-cooled liquid, thus proceeding to the expansion process. In this case, the temperature of liquid at the expansion valve inlet is 31°C. Therefore, the Point 3 of intersection of the pressure line of 1.4MPa abs with the 31°C constant temperature line that tilts toward the right by 1°C immediately before the 30°C constant temperature line is taken as the point where the condensation process is complete.

Fig.2-16



Note: The pressure also varies while showing a slight drop in the condensation process, while the pressure is assumed to be constant on the P-h Chart.

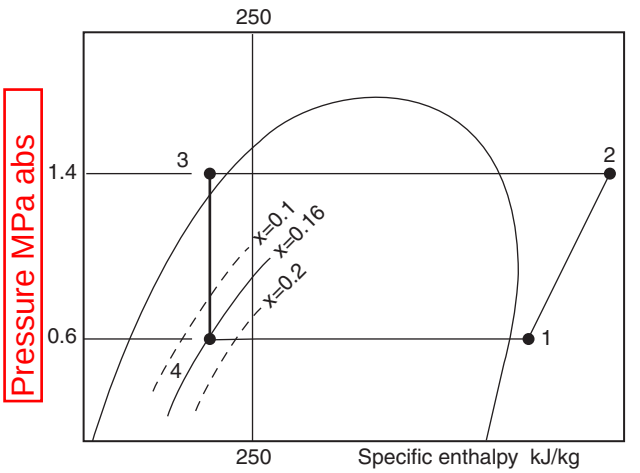
4. Expansion process

The expansion process starts from the Point 3. While in this process, a line is drawn according to the changes of the constant specific enthalpy, that is, in parallel with and perpendicular to the specific enthalpy line up to the Point 4 of intersection with the line of the evaporating pressure of 0.6MPa abs.

The distance between the Point 4 where the evaporation starts and the Point 1 represents the evaporation process.

The expansion process is performed according to the constant change of the specific enthalpy. Even though there are no external heat exchanges, the temperature of the liquid refrigerant falls from 31°C to 6°C. The reason is that when the liquid refrigerant pressure is reduced due to the frictional resistance while passing through the expansion valve or capillary tube, part of the liquid instantaneously vaporizes to decrease the liquid temperature.

Fig.2-17



Note: It is understood that, even though the refrigerant is in the low-temperature low- pressure liquid state when it is discharged from the expansion valve, actually moist vapor having a dryness factor of 0.16 enters the evaporator.

Exercise 2

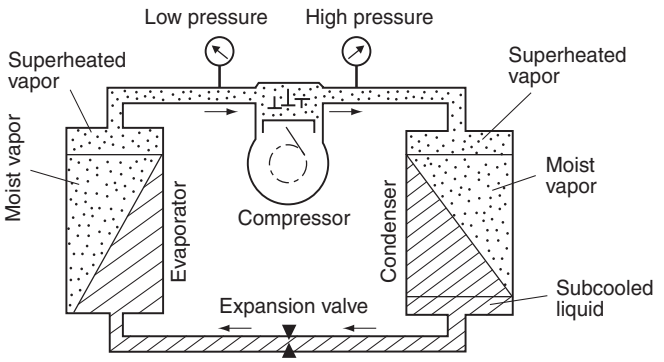
Draw a refrigeration cycle on the P-h Chart under the above-mentioned conditions. Then, read the following numerical values of the four Points 1, 2, 3, and 4. (If the column which cannot be read from the Chart, fill it with an oblique line.)

2.2 How to draw refrigeration cycle

2.2.1 Vapor compression refrigeration cycle

Chiller and air conditioners consist of four major components such as evaporator, compressor, condenser, and expansion valve. The refrigerant flows through these components and the process of evaporation → compression → condensation → expansion repeats to carry out refrigeration. This process is called the refrigeration cycle.

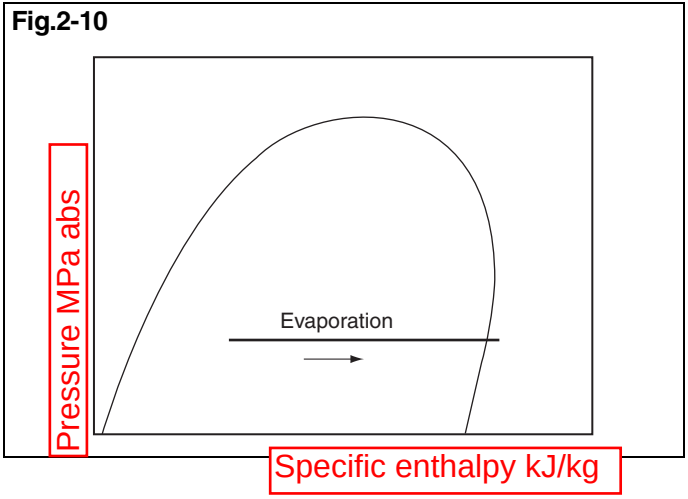
Fig.2-9



1. Evaporation (Change of phase in the evaporator)

The evaporation is a process in which the low-temperature low-pressure liquid refrigerant evaporates while removing heat from the indoor air or moisture. On the P-h Chart, this change of phase is represented by drawing a line from left to right with a constant pressure line, that is, a horizontal line.

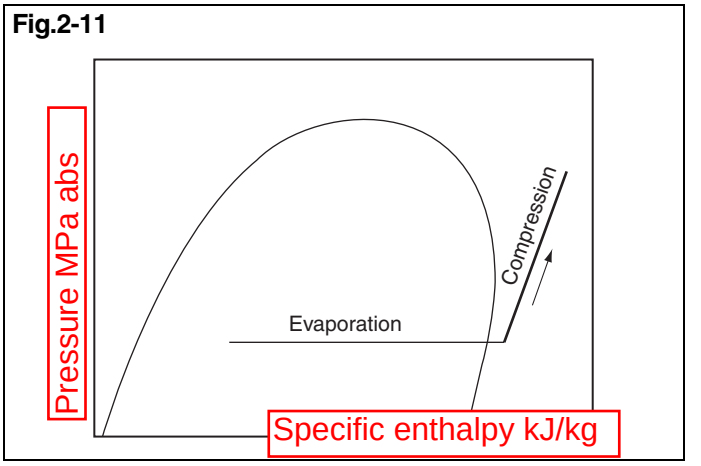
Fig.2-10



2. Compression (Change of phase in the compressor)

The compression is a process in which the compressor sucks in gases generated through the evaporation process and compresses the gases into high-temperature high-pressure superheated vapor. This process is taken as the adiabatic compression, that is, the constant specific entropy change.
In general, the suction gas into the compressor has a superheated degree of 5°C. Therefore, on the P-h Chart, this change of phase stage is represented by drawing an upward-slopping line from the right side of the saturated vapor line, along the constant specific entropy line.

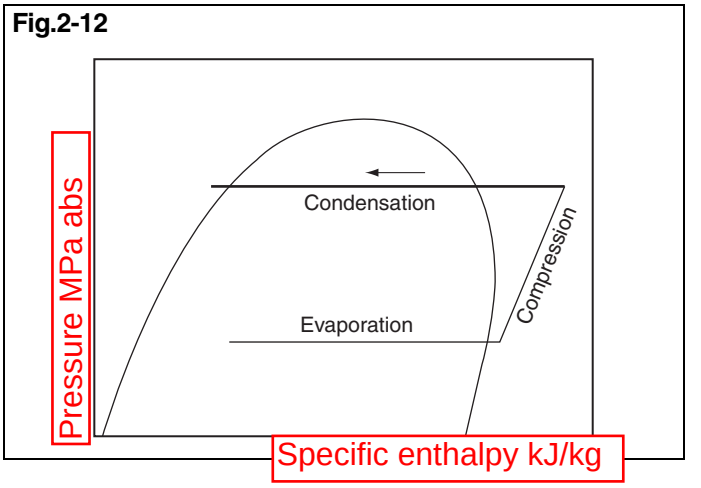
Fig.2-11



3. Condensation (Change of phase in the condenser)

The condensation is a process in which the high-temperature high-pressure discharge gas from the compressor is condensed (liquefied) through cooling water or outdoor air in the condenser. On the P-h Chart, this change of phase is represented by drawing a line from right to left with a constant pressure line, that is, a horizontal line.

Fig.2-12



4. Expansion (Change of phase in the expansion valve or capillary tube)

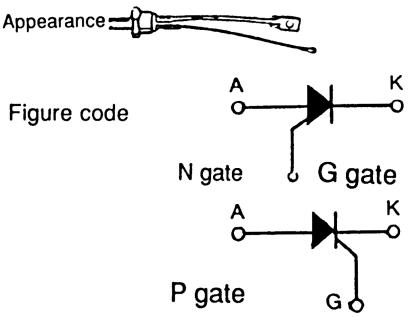
The expansion is a process in which the pressure of the condensed liquid refrigerant is reduced through the expansion valve (or capillary tube) to an evaporation pressure required. In this process, since there is no heat transmission between the refrigerant and the surroundings, the phase changes according to the constant specific enthalpy.
In general, the liquid refrigerant at the inlet of the expansion valve is sub-cooled by 5°C below the condensing temperature. Therefore, on the P-h Chart, this change of phase is represented by drawing a vertical line from top to bottom from the left side of the saturated liquid line.

(4) Thyristor [SCR] (SCR : Silicon Controlled Rectifier)

Thyristor is a power control element consisting of P and N type semiconductors connected in 4 layers.
This is used in speed control of DC motor, light control device of electric lamp and non-contact switch utilizing its rectifying and switching functions.
Moreover, the thyristor can turn on and off the extremely high voltage/current of several thousand volts and several thousand ampere with one element which is so small that it is placed on our palm.

Thyristor (SCR: Silicon Controlled Rectifier)

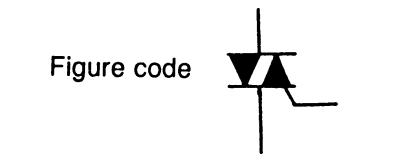
Thyristor



(5) Triac

Triac is a 3-polar dual direction thyristor which can flow electric current in both directions (AC) and functions with both positive and negative gate voltages. The functions are the same as those obtained by combining thyristors in parallel and in reverse direction.

Triac

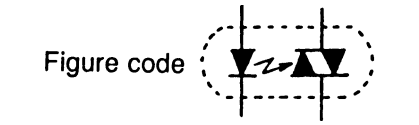


Triac has a 5-layer structure of NPNPN, which is the same as SSS, and is used for AC non-contact switch, electric heater control, light adjusting device, three-phase motor control and temperature control of copy machines (Xerox, PPC). In Daikin products, it is used for phase control of indoor unit fan of room air conditioners and sky air systems.

* Photo triac

Photo triac functions when light is emitted instead of applying gate voltage, and is often used as light receiving element of photo coupler. It is also often incorporated into phase control circuit of fans by combining with light emitting diode (LED).

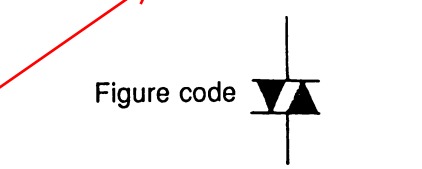
Photo triac



(6) ~~Dyac~~

~~Dyac~~ is often used as the trigger element in AC phase control circuit such as muffling access ignition device of water boilers, etc..
Another name of ~~dyac~~ --- Dual direction diode thyristor

~~Dyac~~

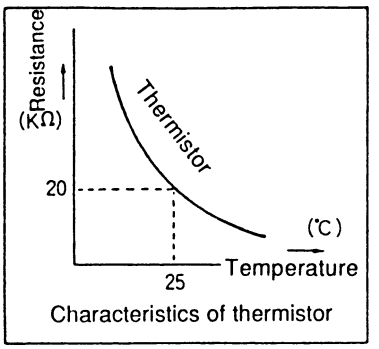


Diac

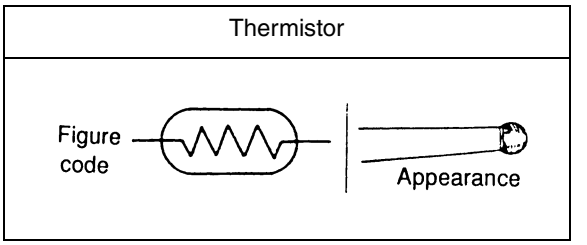
(7) Thermistor

Thermistor has a characteristics that the resistance lowers as the temperature rises, which is opposite to that of normal resistor. (NTC thermistor)
By utilizing this characteristics (resistance change), thermistors are incorporated into the sensors of electronic thermostats in room air conditioners, Sky-Air system and boilers.

Code and characteristics of thermistor



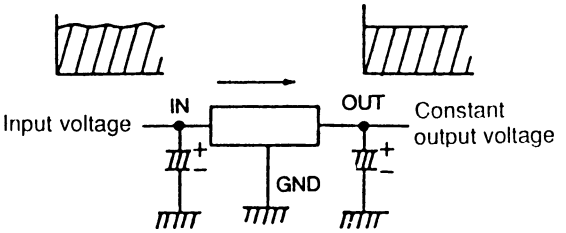
Characteristics of thermistor

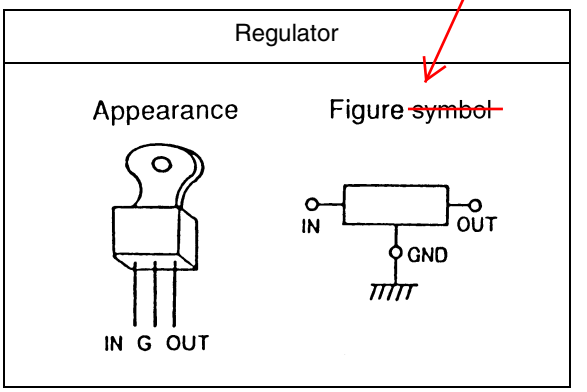


code

(8) Regulator

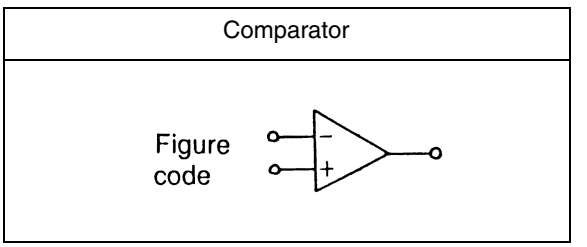
Regulator is an IC for power stabilization. The regulator can control the output voltage to a constant level regardless of the input voltage.
The accuracy of regulator is higher than that of zener diode, and can take a heavy power source out.





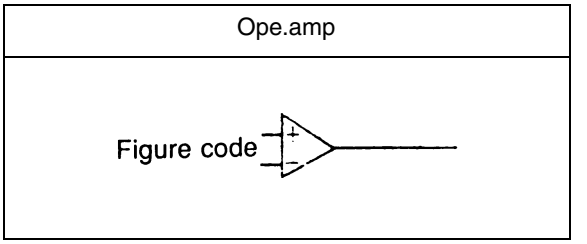
(9) Comparator

Comparator compares two input voltages and outputs the result as "H" or "L". The input terminal has positive side and negative side, and if the voltage input to positive side is higher than that input to negative side, the results is output as "H", while "L" is output in the opposite case.
The figure below shows this function using a relay as an example.



(10) Ope. amp

Ope. amp is an integrated circuit called as calculation amplifier. It is used for 1) calculation, 2) Impedance change, 3) measurement control and 4) oscillator, etc. by connecting to an appropriate external circuit.



TYPE

6.10.1.6 Specifications of Service Checker ~~TPYE~~ III

Item	Specifications
External dimensions (excluding projecting sections)	180 (width) × 150 (depth) × 45 (height) mm
Weight	Approx. 700g
Power supply	9VDC, 300mA (Outside:+) (Use an AC adapter or battery of [TYPE3 Power Unit (220V)]).
Power consumption	Approx. 1.2W
Battery drive time	Approx. 8 hours after complete charging (when using a battery attached to [TYPE3 Power Unit (220V)]).
Temperature and humidity conditions	-10 to 55°C (-10 to 35°C for AC adapters), 95% RH or less (no condensation)
RS232C interface	Asynchronous (19200bps), D-sub 25-pin female (straight connection to a personal computer)
Sensor input section	Temperature at 6 points(one point for discharge pipe), pressure at 2 points (high pressure and low pressure) Two out of the 6 points can be switched to receive to voltage signals (0 to 1V or 0 to 5V).

TYPE

6.10.1.7 Standard configuration

Product name	Parts number	Description	
Checker TYPE3	999135T	Service Checker ~~TPYE~~III Cable for VRV-system air conditioner for building Serial connector conversion cable (Used when connecting M5, RAcable to the Service Checker) RS-232C cable for personal computers (D-sub 25-pin male/D-sub 9-pin female straight)	
TYPE3 Power Unit (220V)*1	999142T	AC adapter	Input: 220VAC, 50Hz Output: 9VDC, 500mA (Outside: +) Temperature condition: -10 to 35°C
		Battery: Ni-Cd battery	
		Charger: 220VAC input, 50/60Hz (Complete charging: approx. 16 hours)	
TYPE3 Software (English)	999143T	Compatible with English-version Windows95/98/Me/NT4.0/2000/XP	
TYPE3 Instruction Manual (English)	999144T	Instruction manual of TYPE3 software (English)	

Purchase the above four items (total of 181,000yen).

6.10.1.8 Optional Items

Product name	Parts number	Description
M5, RA cable*1	999140T	Used when connecting to a Super Multi or room air conditioner via PCB connection. No need to purchase this cable if customers have TYPE2 Expansion Kit (999112T).
Sensor Kit*1	999107T	High temperature thermistor (-30 to 150): 1pc. Low temperature thermistor (-30 to 70): 3pcs. Air thermistor (-10 to 50): 3pcs. High pressure sensor (0 to 30kg/cm^{2}G): 1lot Low pressure sensor (0 to 10kg/cm^{2}G): 1lot

6.10.1.9 Accessories

Product name	Parts number	Description
TYPE3 cable for VRV-system air conditioner for building*1	999141T	A set of cable of VRV-system air conditioner for building cable and serial connector conversion. Attached to the Checker TYPE3
TYPE2 spare battery*1	999113T	Used to drive the Serivce Checker ~~TPYE~~ III. Attached to the TYPE3 Power Unit (220V)

TYPE

- Please follow Daikin's purchasing procedure.
- Pentinum is a registered trademark of Intel Corporation. Other product names mentioned above are trademarks or registered trademarks of respective companies.
- The above specifications may be modified for improvement without any advance notice.

Note :

Refer to the operation manual of Service Checker Type III for more details.

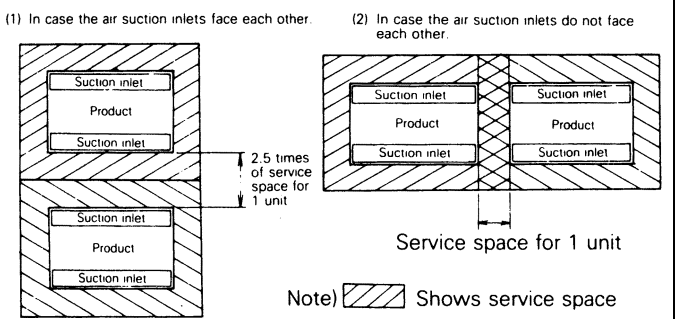
7.5 Cautions for installation

Before installing the unit actually at the predesigned position, make sure to leave the service space indicated on the respective installation and technical manuals around the unit, and at the same time, examine various surrounding conditions.

7.5.1 Service space

- In general, space for installation works is over 600mm and space for service works is over 1200mm. With regard to the details, see the technical manual.
- In case two air cooled condensing units are installed in parallel.
  Minimum service space is shown below.
  However, the minimum service space differs with models, so follow the respective installation or technical manual as for the details.

Fig.7-20

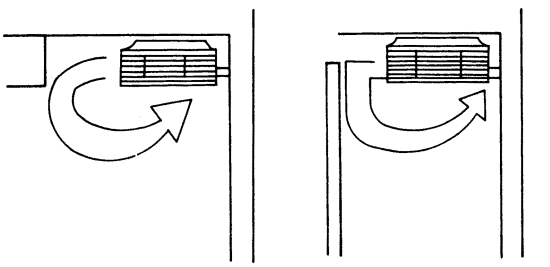

(1) In case the air suction inlets face each other.
(2) In case the air suction inlets do not face each other.
Suction inlet
Product
Suction inlet
2.5 times of service space for 1 unit
Service space for 1 unit
Note) Shows service space

7.5.2 Installation of units

- Consider air distribution of a room based on structure of a room and arrangement of occupants and furniture.
- Install the unit in such a place where wall or obstacles do not interrupt the air ways in and out of the unit. (If the air way is disturbed, predesigned cooling efficiency is not obtainable, and furthermore dew forms on the casing, which may be resulted in water leakage.)
- Avoid installing the unit in such a place which is near the door or kitchen so as not to draw unnecessary volume of air or stale air.
- In case the unit is mounted in a wall, carefully install it not to transmit operation vibration to the wall. Leave a sufficient space for providing after-sales service.

Examples of bad installation
If distributed air is short-circuitted, cooling or heating capacity will be greatly reduced.

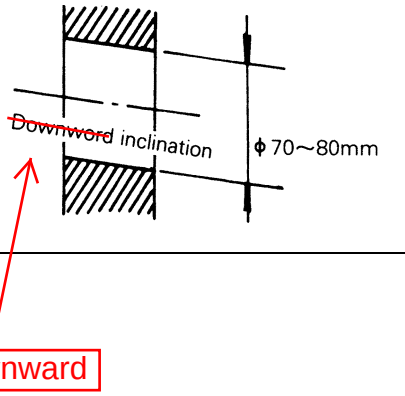
Fig.7-21



7.6 Making a pipe hole

Make a hole in the wall. In case of room air conditioners, suitable hole diameter is 70~80mm.
The location of a hole should be lower than the drain outlet so that drain water can be smoothly extracted outsides. In addition the hole should be inclined downwards to the outdoor as shown in the figure below.

Fig.7-22



Chapter 11 Psychrometric chart

11.1 Air

Atmospheric air is referred to as "air", which means the moist air in terms of air conditioning.

11.1.1 Properties of moist air

Moist air is a mixture of dry air and 1 to 3% mass of water vapor.

1. Properties of dry air

The composition of dry air in the standard state (temperature: 0°C, pressure: 760mmHg {101.325kPa}, acceleration of gravity g = 9.80655 m/S^2) is as follows.

Table 11-1

Composition	Nitrogen (N_2)	Oxygen (O_2)	Argon (Ar)	Carbon dioxide (CO_2)
Volumetric (%)	78.09	20.95	0.93	0.03
Gravimetric (%)	75.53	23.14	1.28	0.05

*1 Constant pressure specific heat of dry air Cpa
=0.240 [kcal/kg • deg] =1.005 {kJ/kg • K}

*2 Enthalpy of dry air ha
=0.240t [kcal/kg] =1.005t {kJ/kg}

This means the enthalpy of dry air at arbitrary temperature and pressure based on the condition that the enthalpy of dry air is 0 at a temperature of 0°C and standard atmospheric pressure.

2. Properties of water vapor

Constant pressure specific heat of water vapor Cpw
=0.441 [kcal/kg • deg] =1.85 {kJ/kg • K}
Evaporation latent heat of water vapor r
=597.3 [kcal/kg] =2501 {kJ/kg}
Enthalpy of water vapor hw
=r+Cpwt=597.3+0.441t [kcal/kg] =2501+1.85t {kJ/kg}

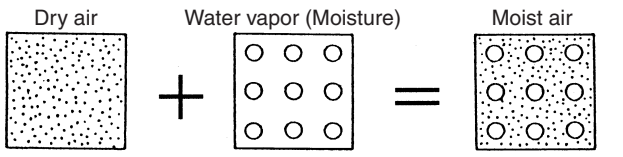
Water vapor enthalpy hw at arbitrary pressure and temperature is shown as a function of temperature t°C alone, under the condition that the enthalpy of saturated water at 0°C is 0, and the pressure and temperature are not so high.

11.1.2 Moist air

It is convenient to assume that the moist air is an ideal gas that is mixture of dry air of 1kg in a certain composition and water vapor of X [kg] variable with state.
Thus, concerning moist air, a variety of numerical values are not handled for the unit weight of mixed gas of dry air and water vapor, while the mixed gas of 1 kg of dry air and X [kg] of water vapor, that is, (1+ X) kg of air is used as one unit weight.

Namely, the following figure represents the weight, pressure, and volume of the moist air by the expressions.

Fig.11-1



Weight	1 [kg]	+	X [kg]	=	1+X [kg]
Volume	V	+	V	=	V
Pressure	Pa [kg/cm^2]	+	Pw [kg/cm^2]	=	P [kg/cm^2] =1.03323kg/cm^2
	Pa{kPa} (Partial pressure)	+	*Pa{kPa}* (Partial pressure)	=	*P {kPa} =101.325kpa (Total pressure)*

11.1.3 How to represent water vapor (Humidity) in moist air

There are different kinds of method available to represent the humidity.

1. Relative humidity [ϕ=%]

The relative humidity is the ratio of the moist-air specific weight to the saturated-air specific weight, or the ratio of the water vapor partial pressure Hw [mmHg] {kpa} in given moist air to the moisture partial pressure Hs [mmHg] {kPa} in saturated moist air at the same temperature.

(a) y = Specific weight [kg/m^3] (Specific weight = 1/Specific volume)
This is the weight of water vapor [kg] contained in 1-m^3 moist air.

(b) Saturated moist air

○ When the temperature t of moist air is equal to the temperature t of saturated water vapor corresponding to the partial pressure Hw of the water vapor, the air is called "saturated moist air" or "saturated air" in short.

○ When pressure and temperature are determined, the limit of water vapor containable in the said air is also determined. This air containing water vapor up to the limit is called saturated air.

2. Absolute humidity [X = kg/kg]

X in Fig. 1.1 represents the absolute humidity itself. The weight ratio of water vapor contained in the moist air becomes X/1 [kg/kg] to 1-[kg] dry air contained in the moist air. In other words, this is the ratio of the moisture weight to the dry air weight, both of which are contained in the moist air.

[Example of calculation]

① From Equation (5.8),

$q_p = G\,(h_3 - h_5)$ [kcal/h]

$q_p = \frac{1}{3000} \times G\,(h_3 - h_5)$ {kw}

$h_5 = h_3 - \frac{q_P}{G} \fallingdotseq h_5 - \frac{q_P}{1.2 \times Q}$

$h_5 = h_3 - \frac{3600 \times q_P}{G} \fallingdotseq h_3 - \frac{3000 \times q_P}{Q}$ {kJ/kg}

h6

② Substituting h_3 and h_5 into Equation (5.13), the Equation will be

$h_5 = h_5 - \frac{(h_3 - h_5) \times BF}{CF}$

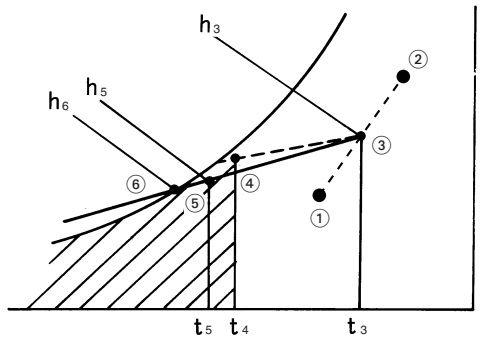
Find BF according to the technical data to calculate the h_6.

③ Draw a straight line between Point ③ and Point ⑥ obtained from h_5 on the psychrometric chart and find t_5 through the intersection of the straight line and h_5.

(c) Availability of model assumed

If the air conditioner outlet temperature t_5 found in Section (b-3) is lower than the design discharge temperature t_4 and located below the apparatus SHF line found by Equation (5.1), the design air conditions are satisfied, making it possible to proceed with calculations according to the model assumed. Fig. 11-28 shows that on the psychrometric chart.

Fig.11-28



It is good if the air conditioner outlet temperature t_5 falls in the shaded area in the above figure. If there is too large difference between the air conditioner outlet temperature t_5 and the design discharge temperature t_4, it is required to use a model of smaller capacity and reexamine the planning since the capacity of the assumed model is too large.

2. When a model is not assumed

Generally speaking, in this case, set up conditions and proceed with planning with a concept to newly produce an air conditioner conforming to the apparatus. Namely, Referring to information in Section 5-1 (3) "(b) When the airflow rate has not been determined", tentatively determine the airflow rate, then, take this airflow rate as a reference to determine the model of air conditioner.

Example

When finding a cooling load required to maintain the conditions of a given room at 26°CDB and 50%RH, qs = 8,000 kcal/h {9.30kw} and qL = 2,000 kcal/h {2.32kw}. Find the SHF of this room. When the bypass factor BF of the evaporator is 0.11, what is the dry-bulb temperature required to discharge air at a point on the SHF line?

[Solution]

From Equation (5.1),

$SHF = \frac{q_s}{q_s + q_L} = \frac{8{,}000}{8{,}000 + 2{,}000} = 0.8$

Use the psychrometric chart of discharge temperature to find the SHF.

$SHF = \frac{q_s}{q_s + q_L} = \frac{9.32}{9.30 + 2.32} = 0.8$

Fig.11-29

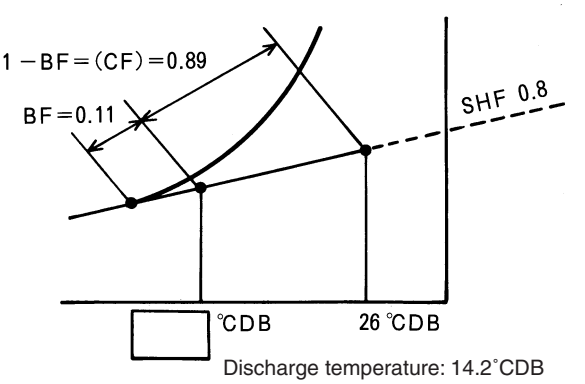
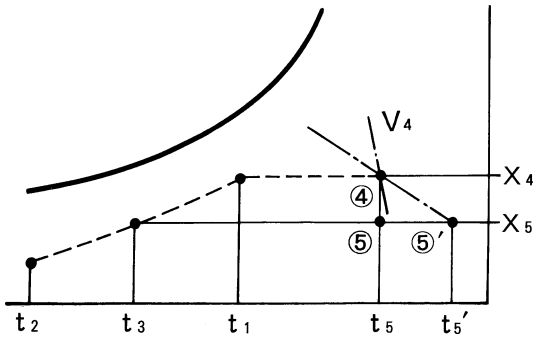


Fig.11-39



X_4: Absolute humidity at outlet point ④ of humidifier ..... (kg/kg)

X_5: Absolute humidity at inlet point ⑤ or ⑤' of heater ..... (kg/kg)

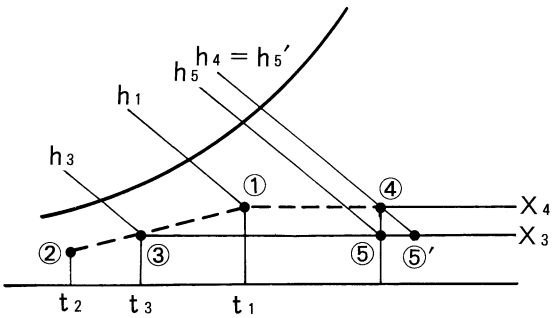
When the humidifying weight is determined, specify the type from the optional accessories list in the Technical Data.

When selecting with evaporative-plate-type humidifier,
Type: KEM104D15,
Humidifying capacity: 5.2 (kg/h), and
Power consumption: 4 (kW)

(h) Summary in heating operation

The cycle is shown on the psychrometric chart.

Fig.11-40



① Indoor point
② Outdoor-air point
③ Mixing point = Heater suction point
④ Design discharge point = Outlet point of humidifier
⑤ Heater outlet point = Inlet of evaporative-plate-type humidifier
⑤' Heater outlet point = Inlet of water-spray-type humidifier
- Heater capacity = h_5' or $h_5 - h_3$
  (h_5': In the case of water-spray-type humidifier
  h_5: In the case of evaporative-plate-type humidifier)
- Indoor load: $h_4 - h_1$
- Outdoor-air load: $h_1 - h_3$
- Humidifying load: $h_4 - h_5$
- Humidifying capacity: $X_4 - X_5$

11.6.2 Selection of model with priority given to apparatus and airflow rate

In cooling operation

1. Find the sensible heat factor.

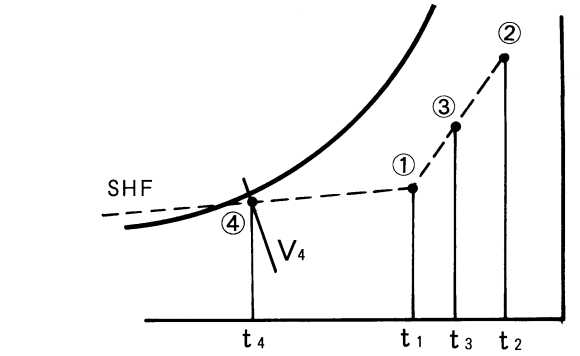
From Equation (5.1),

$$SHF = \frac{q_S}{q_S + q_L}$$

2. Plot the proven conditions on the psychrometric chart.

Indoor condition .....Point ①
Outdoor-air condition
(When outdoor air is taken in).....Point ②
SHF line.....SHF line found in ①.

Fig.11-41



3. Find the airflow rate of apparatus.

$$Q = \frac{q_S \text{ kcal/h}}{0.24 \times \frac{1}{V_4} \times (t_1 - t_4)} = \frac{3600 \times q_S \text{ kw}}{1.005 \times \frac{1}{V_4} (t_1 - t_4)} \quad (q_S : \text{kcal}, q_S : \text{kw})$$

V_4: Assuming the discharge point ④ of apparatus, calculate the specific volume of air. [m^3/kg]

t_4 : Assume the discharge point ④ of apparatus. [°C]

How to assume t_4

In the case of ordinary cooling operation, assume that the difference (t_1 - t_4) in temperature between suction and discharge is 8 to 12 deg. and the relative humidity at the discharge point falls in the range of 80 to 90%.

4. Find the conditions of air at the inlet of evaporator.

(a) When outdoor air is taken in the air conditioner

Find the mixing point ③, which is present on the straight line connecting the outdoor-air point ② and the indoor point ①. The point ③ is defined as the suction point.

(From Equation (2.1))

$t_3 \fallingdotseq K \bullet t_2 + (1 - K) \bullet t_1$ ..... [°C]

$h_3 \fallingdotseq K \bullet h_2 + (1 - K) \bullet h_1$ ..... [kcal/kg]{kJ/kg}

Answers to Exercise 8

① Find the mixed air ③.

From Equation (2.1), $t_3=K \bullet t_2+(1-K)t_1$

$t_3=0.1\times0+(1-0.1)\times20$

$=18$ [˚C]

$h_3=K \bullet h_2+(1-K)h_1$

$=0.1\times1.1+(1-0.1)\times9.4$

$=0.11+8.46$

$=8.57$ [kcal/kg]

According to the above calculation, the mixed air ③ reaches 18˚CDB and 54.5%RH.

② Find the state ④ at the outlet of heating coil.

Substituting numerical value through Equation (4.10):

$$q_H=Q\times\frac{1}{V_3}(h_3-h_1)$$

$$2800=6000\times\frac{1}{V}\times(h_4-8.57)$$

$$h_4=8.57+\frac{2800}{6000\times\frac{1}{V(0.882)}}$$ Assume that V=0.882.

$=8.57+4.12$

$\fallingdotseq12.7$ [kcal/kg] Thus, make sure through the psychrometric chart.

③ Find the state ⑤ of air after humidification

Substituting numerical value through Equation (4.11):

$$L_W=Q\times\frac{1}{V_3}(X_5-X_3)$$

$$10=6000\times\frac{1}{V}\times(X_5-0.0069)$$

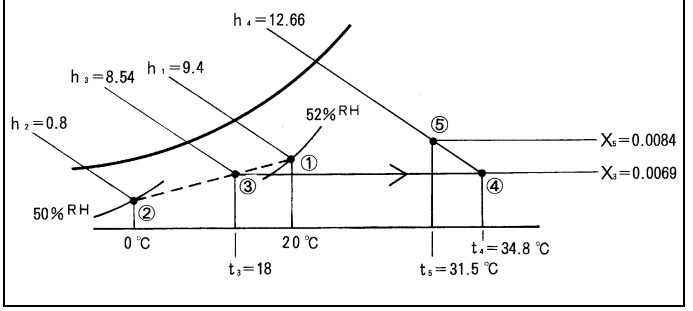
$$X_5=0.0069+\frac{10}{6000\times\frac{1}{V}}$$ Assume that V=0.875.

$X_5\fallingdotseq$ ~~8.57+4.12~~

$=0.0084$

④ Write the numerical values found in the above ① , ② , and ③ on the psychrometric chart.

Fig.11-54



0.0069+0.0015

Answers to Exercise 9

① Find the sensible heat factor SHF.

From Equation (4.1): $SHF=\frac{q_S}{q_S+q_L}$

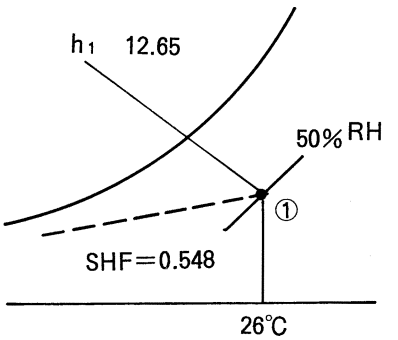
$=\frac{8500}{8500+7000}$

$=0.548$

Write the SHF on the psychrometric chart and find the conditions of suction air of air conditioner.

Enthalpy h_1 of inlet air =12.65 [kcal/kg]

Fig.11-55



② Find the discharge point of air conditioner.

From Equation (5.11): $h_5\fallingdotseq h_3-\frac{q_p}{1.2\times Q}$

$h_2=12.65-\frac{2000}{1.2\times3000}$

$=12.65-5.56$

$=7.09$ [kcal/kg]

Write the enthalpy h_5 at the outlet of air conditioner on the psychrometric chart.

From Equation (5.13): $h_6=h_5-\frac{(h_3-h_5)\times BF}{CF}$

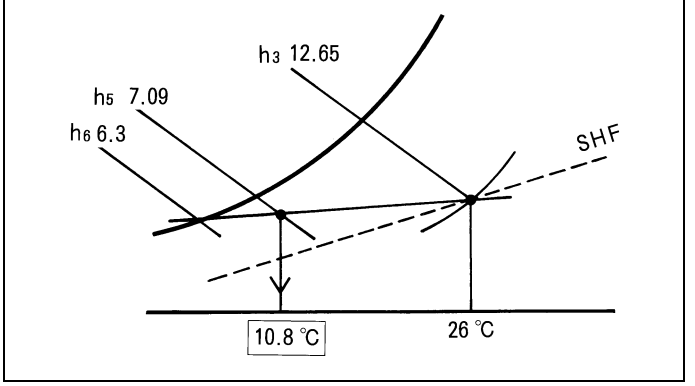
$h_6=7.09-\frac{(12.65-5.56)\times0.1}{(1-0.1)}$

$=7.09-0.79$

$=6.3$ [kcal/kg]

In order to provide the discharge point of air conditioner on the SHF line.

Fig.11-56



Install a re-heater and determine the re-heater capacity.

12.3 Design Conditions

Table 12-1 Composition of heat load

		Heat source	Heat		Heat gain (Cooling load)	Heat loss (Heating load)
			Sensible heat	Latent heat		
Indoor load	External load	1. Roof·wall·partition·floor·ceiling «Solar radiation, night radiation, temp. difference»	○		□	■
		2. Window glass «Solar radiation, night radiation, temp. difference»	○		□	■
		3. Infiltration «Temperature and humidity of infiltrated air»	○	◉	□	■
	Internal load	4. Illuminant «Generated heat»	○		□	
		5. Human body·equipment «Generated heat»	○	◉	□	
Outdoor air		6. Intake fresh air «Temperature and humidity in outdoor air»	○	◉	□	■

Table 12-2 Cooling load conditions

	Dry bulb temp. (DB)	Wet bulb temp. (WB)	Relative humidity (RH)
Outdoor conditions	33°C	27°C	63~~°C~~
Indoor conditions	26°C	19.5°C	55~~°C~~

%

Note:
Since these conditions about indoor and outdoor are included in the coefficient "B" in the Cooling/Heating load list, the figuring out of temperature difference is not required.

Table 12-3 Heating load conditions

Figure out the temperature difference from the following table.

Outdoor temperature °C	Brussels Belgium	Shanghai China	Hong Kong China	Tokyo Japan	Riyadh Saudi Arabia	Buenos Aires Argentina	Paris France	Sydney Australia
	-7	-3	10	-2	4	1	-4	5

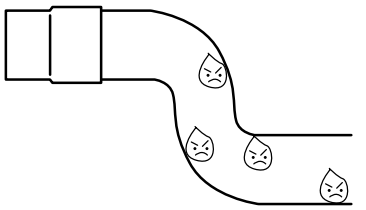
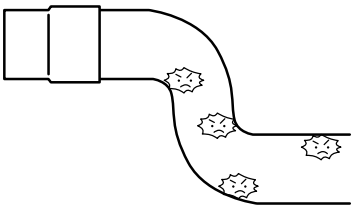
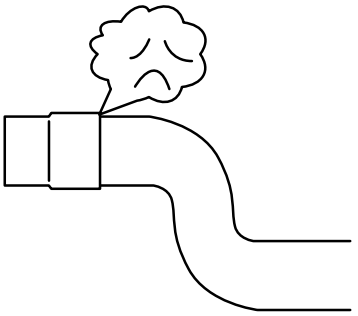
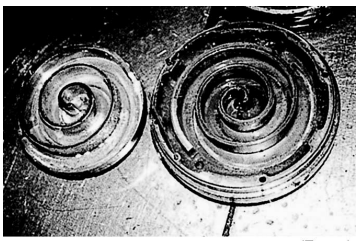
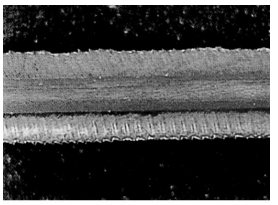
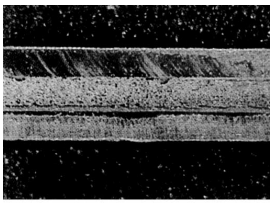
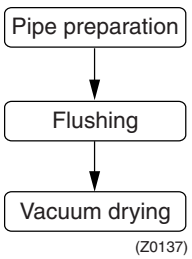
Note:
1) These data are drawn out from ASHRAE HANDBOOK
2) When night heating is regarded as importance, reduce further 2 degrees from the above temp.

Table 12-4

Indoor temperature °C	State of action	Examples
22	Seated at rest or very light work	Office, theater, residence, restaurant, etc.
20	Little active	Factory (light work), school, store, etc.
18	Very active	Factory (Heavy work), dance hall, etc.

13.3 Refrigerant piping

13.3.1 Three basic rules of refrigerant piping

	(1)Drying (no moisture)	(2)Cleaning (free of contamination)	(3)Tightening (air-tightness)
	There shall be no moisture in the pipe.	There shall be no dust in the pipe.	There shall be no refrigerant leak.
Item	 (Z0134)	 (Z0135)	 (Z0136)
Cause	• Water entering from outside, such as rain. • Moisture due to dew condensation occurring inside the pipe.	• Oxidized film generated during brazing. • Entering of foreign items such as dust, particles and oil from outside.	• Insufficient brazing • Inadequate flaring or insufficient tightening torque. • Inadequate tightening of flange connection.
Problem	• Clogging of expansion valve, capillary tube, etc. • Insufficient cooling or heating. • Degradation of refrigerant oil. • Malfunction of compressor.	• Clogging of expansion valve, capillary tube, etc. • Insufficient cooling or heating. • Degradation of refrigerant oil. • Malfunction of compressor.	• Gas shortage • Insufficient cooling or heating. • Temperature increasing of discharge gas. • Degradation of refrigerant oil. • Malfunction of compressor.
	<For reference>  (Z0186) Compressor is corroded due to moisture.	 Not clogged (Z0187)  Clogged (Z0188) Capillary is clogged with dust.	
Preventive measure	 (Z0137)	• Same as the items on the left. • Do not use tools or devices previously used with a different type of refrigerant.	• Follow the basic brazing procedure. • Follow the basic flaring procedure. • Follow the basic flange connection procedure. • Conduct an air-tightness test (gas leak check).
Remarks	Pipe preparation ~~---See page 13.~~ Flushing ~~---See page 14.~~ Vacuum drying ~~---See page 22.~~	Basic brazing procedure ~~---See page 15.~~ Basic flaring procedure ~~---See page 16.~~ Air-tightness testing procedure ~~---See page 19.~~ Gas leak check ~~---See page 20.~~	

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■ Merits and demerits of cleaning using chemical

- There is selectiveness of scales, but almost all scales can be removed, if the chemical is selected precisely. On the other hand, if the mistake is made in the selection, the scale cannot be removed, and more, in some cases, abnormal corrosion is brought about.
- In some cases, neutralization-treatment of drain is required, after cleaning.
- Even the cleaning of large-capacity is possible in a short time.
- Even the complicated water circuit can be cleaned.
- Take care of metal corrosion by the cleaning chemicals.
- Generally, this way is too expensive.

■ Merits and demerits of cleaning using brush

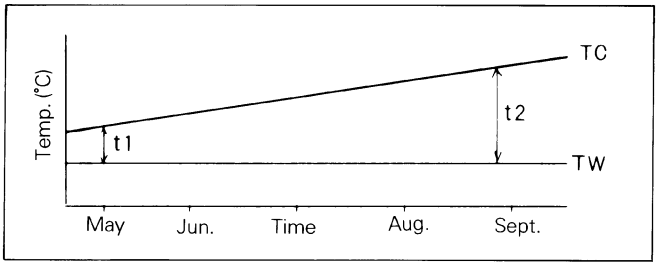
- There is selectiveness of scales comparatively a little. And very hard scales cannot be removed.
- This is almost physical work, so personnel expenses are too high.
- In case of complicated or closed-type water circuit, a brush cannot be inserted, that is the cleaning is impossible.
- As the chemicals is not used, there is no fear of the drain pollution.
- Generally, this way can be cheap.
- Effect of cleaning can be confirmed visually in the working.

3. Is cleaning necessary or unnecessary?

There are various ways to judge of the scale coating, but it is general and certain way to judge be the degree of fall of the heat exchange efficiency.
That is, when full load operating of the cooling (refrigerating) system, 'the outlet temperature of the cooling water flowing in the condenser' is compared with 'the condensation temperature of the refrigerant'. And then this difference is compared with the value at the clean time of the cooling pipe.
Finally, it is judged by how much the former has increased.

Condensation temp. ~~Of~~ refrigerant: This is found by conversion to the saturation temperature of the refrigerant from the indicating pressure of the high-side pressure gauge.

The strong point of this way is that the both temperature differences are almost constant, even though the volume of cooling water changes more or less. So, there are few cases of misjudgement.



Provided,
TC : Condensation temperature
TW : Cooling water temp. at condenser outlet.
t1 :Temp. difference when cooling pipe is clean.
t2 :Temp. difference when scale adheres.

Do not be confused by the sudden stop of the operating cooling (refrigerating) equipment, even though the high pressure switch does not get to the function.
For this, it is necessary to examine the increasing rate of "t2 — t1" and clean the scale in advance. Generally when "t2 — t1" becomes over 3 to 5°C, cleaning is necessary.

4. Judgement after cleaning

The simplest and the most certain way is to confirm visually the state of coming off the scale.
But, in some cases the visual confirmation is impossible because the recent heat exchanger in a cooling (refrigerating) equipment has hermetic or other complicated structure. For this, it is important to compare the before and after cleaning, using the ways mentioned above in the clause 3. when you neglect this (confirmation of cleaning effect), even though the high pressure is cut by other reasons than scale, sometimes it may be judged that the cleaning made a mistake. More, the way of judgement of the state of scale adhesion only by high pressure is not proper, because the state changes depending on the temperature or the volume of cooling water.

5. How to select chemicals for cleaning

An important factor in the chemical cleaning is to select the proper chemicals depending on the type of scales. As a matter of fact, analysis of composite scales should be consulted our Daikin S.S. or the specialist of water treatment.

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